CO2 CRC COOPERATIVE RESEARCH CENTRE FOR GREENHOUSE GAS TECHNOLOGIES

Reducing greenhouse gas emissions to the atmosphere

Regional Characterisation of a Major Storage System: Gippsland Basin, Southeast Australia

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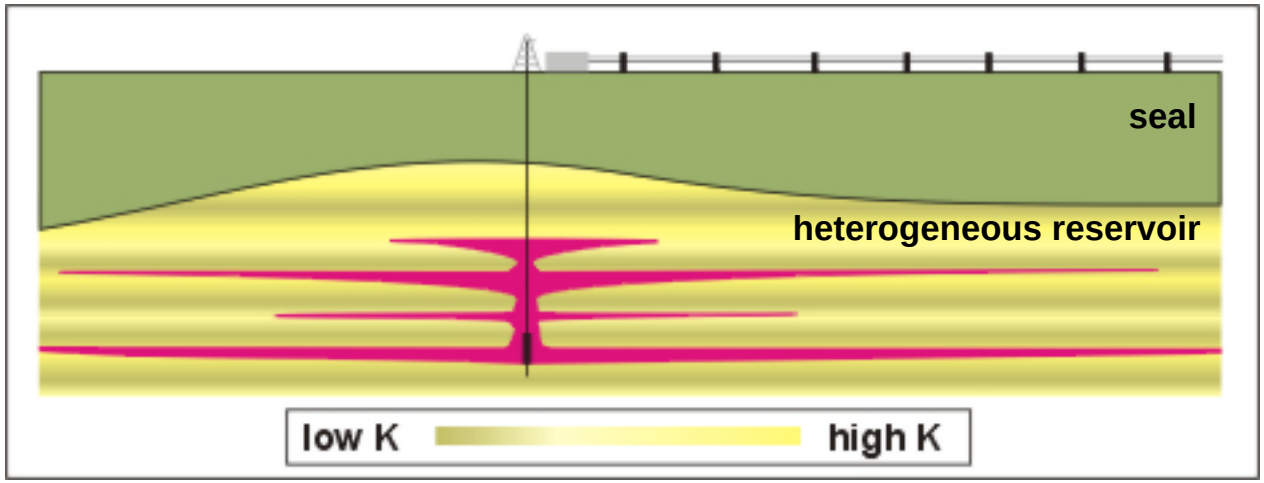
Presentation Outline

- Introduction
- Workflow for detailed site characterisation
- Gippsland Basin, southeast Australia
  - Base regional seal migration pathways
  - Kingfish Field: sequence stratigraphy and depositional model
  - Injectivity: reservoir quality, geometry & connectivity
  - Containment: seal capacity, migration pathways, trap mechanism, geomechanical assessment, hydrodynamic analysis
  - Capacity: 3D geological model & pore volume
  - Numerical flow simulation
- Conclusions

Introduction



Amount of CO_2 geologically stored influenced by:

- Rate of CO_2 migration
- Style of multiphase flow
- Rate of CO_2 dissolution
- Rate of chemical reaction with minerals

Controlled by many variables, including:

- Reservoir and seal structure
- Stratigraphic architecture
- Reservoir heterogeneity
- Faults/fractures
- Pressure/temperature conditions
- Hydrodynamics and chemistry of *in situ* formation fluids

(CO_2 concept model courtesy of Robert Root)

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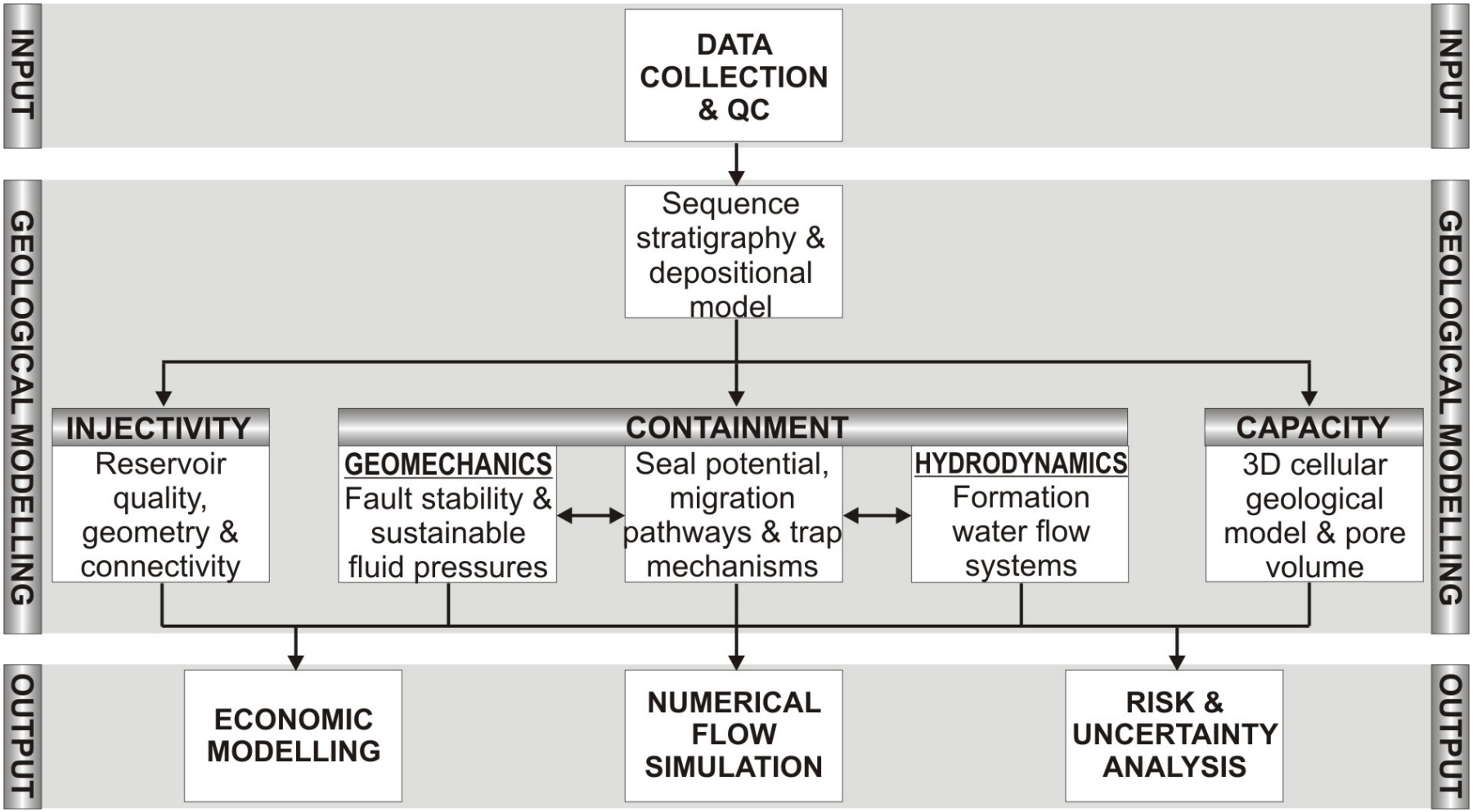
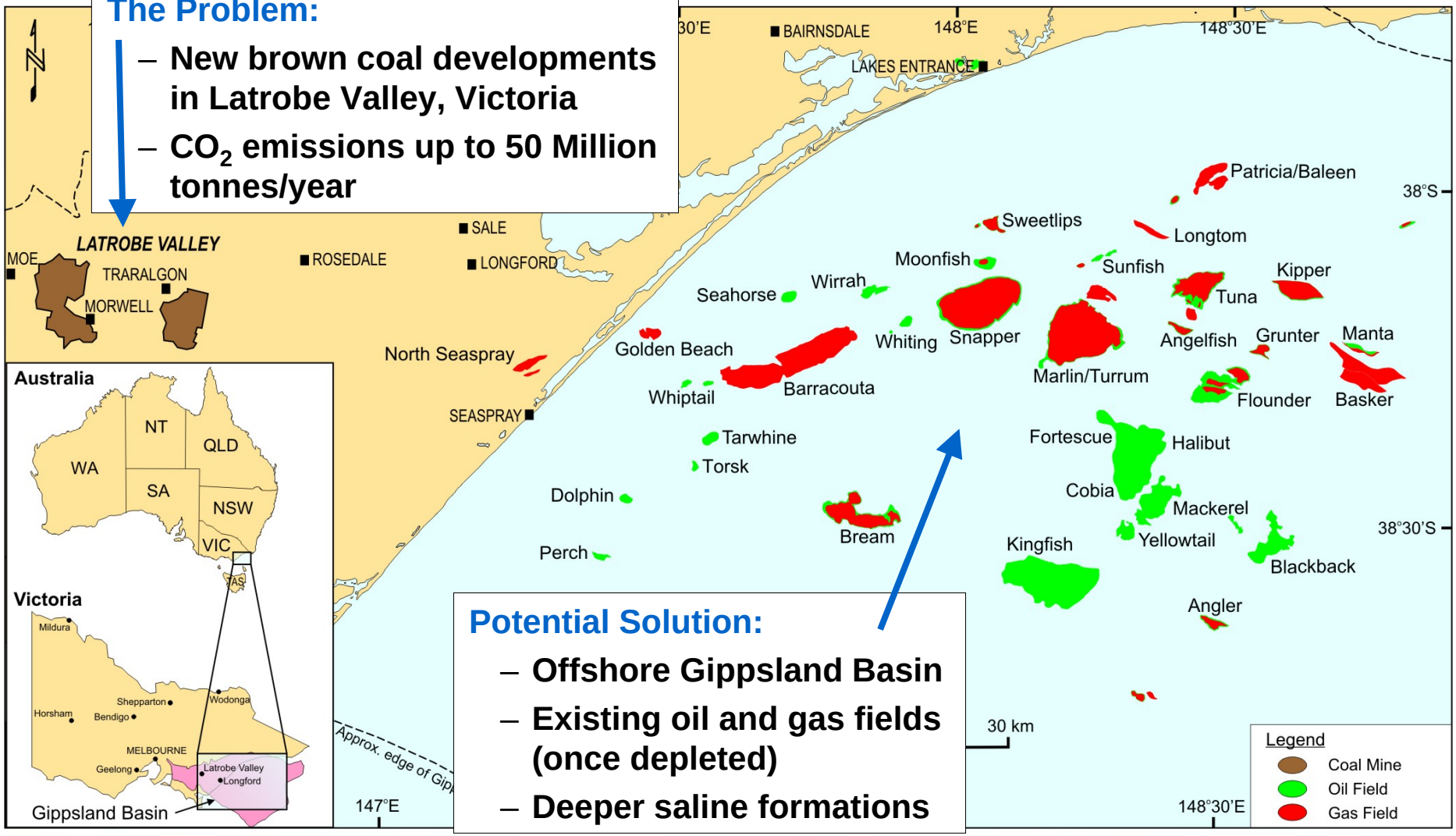
Site Characterisation Workflow



Gippsland Basin, Southeast Australia

The Problem:

- New brown coal developments in Latrobe Valley, Victoria
- CO_2 emissions up to 50 Million tonnes/year



Potential Solution:

- Offshore Gippsland Basin
- Existing oil and gas fields (once depleted)
- Deeper saline formations

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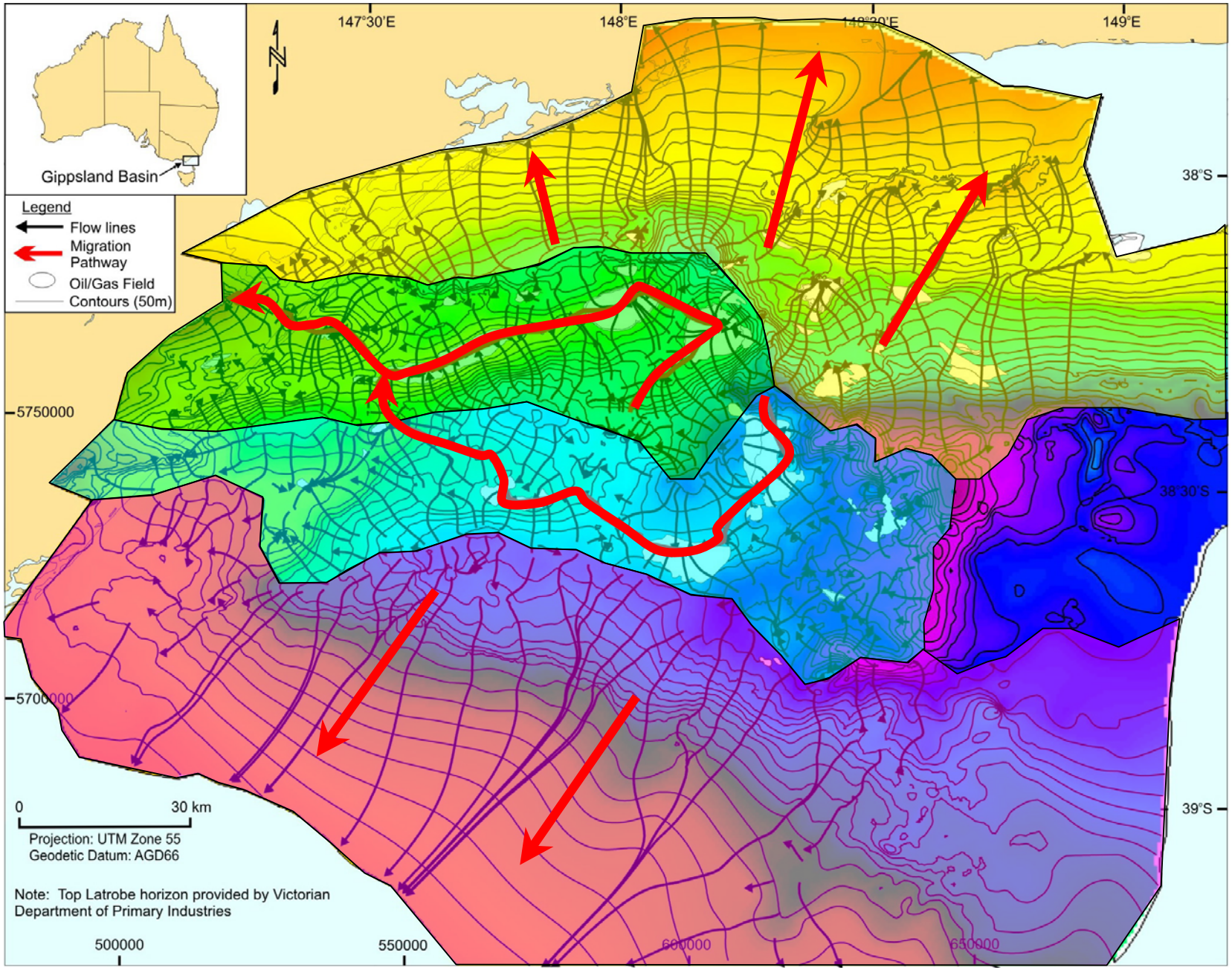
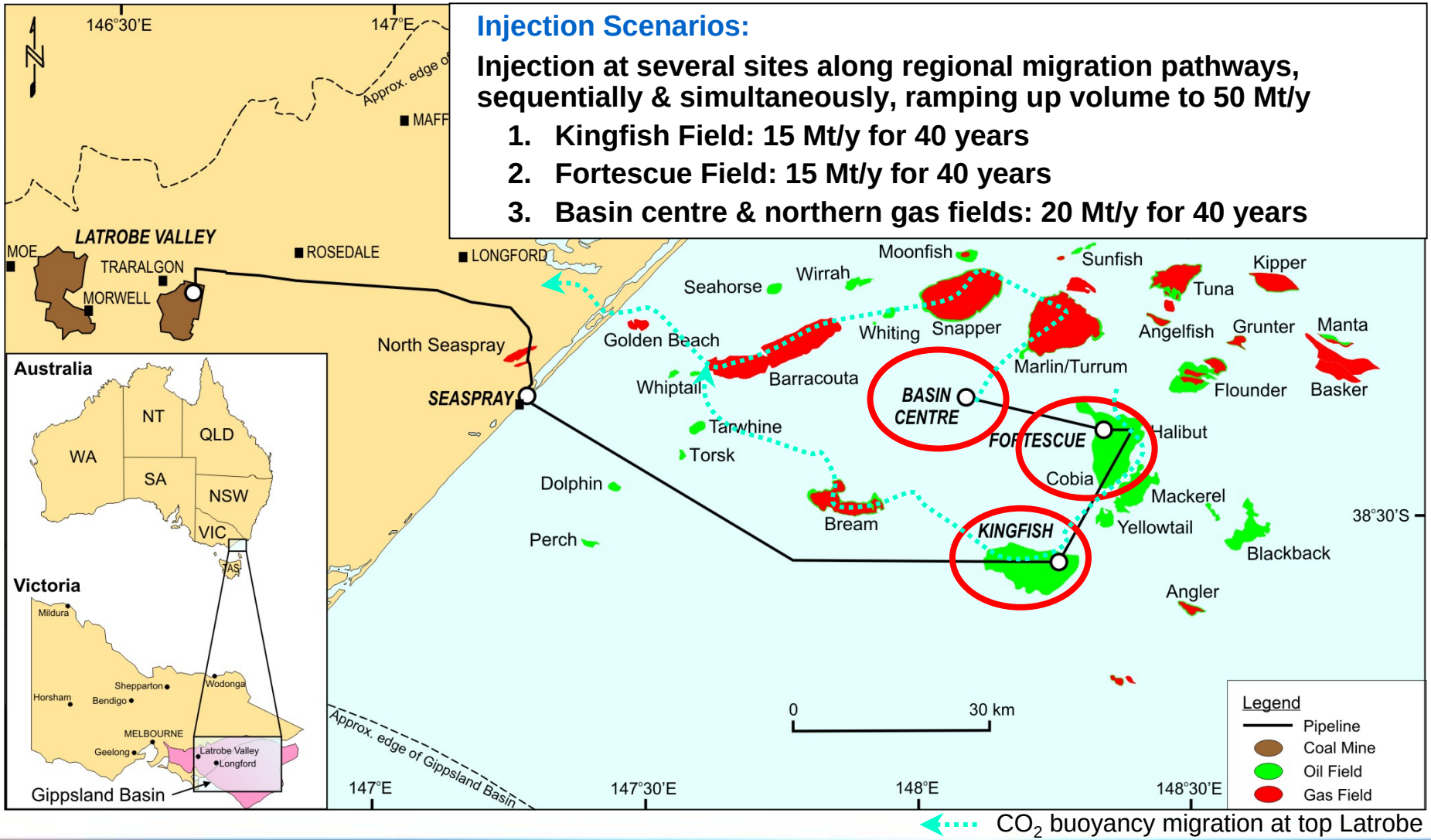
Buoyancy migration pathways at base regional seal



Selected Site Scenarios



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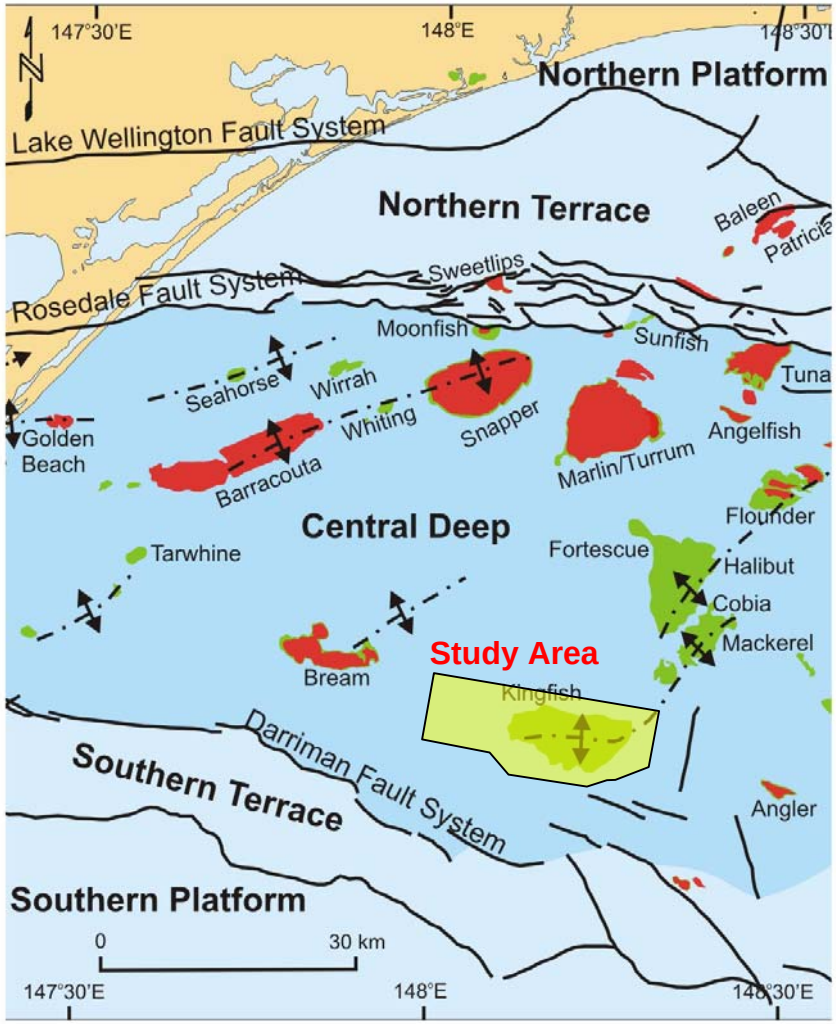
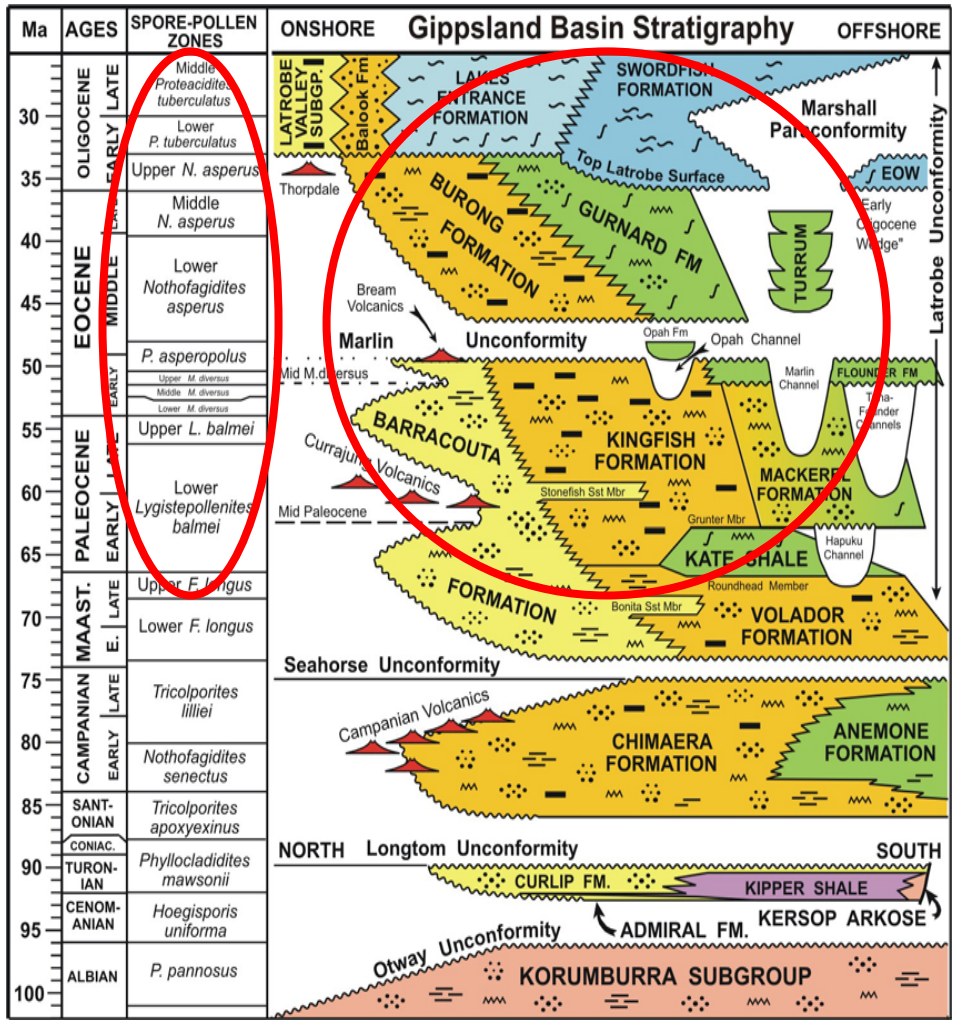
Detailed Characterisation: Kingfish Field

Location map of Gippsland Basin



(modified after Power et al., 2001)

Stratigraphic column



(after Bernecker & Partridge, 2001)

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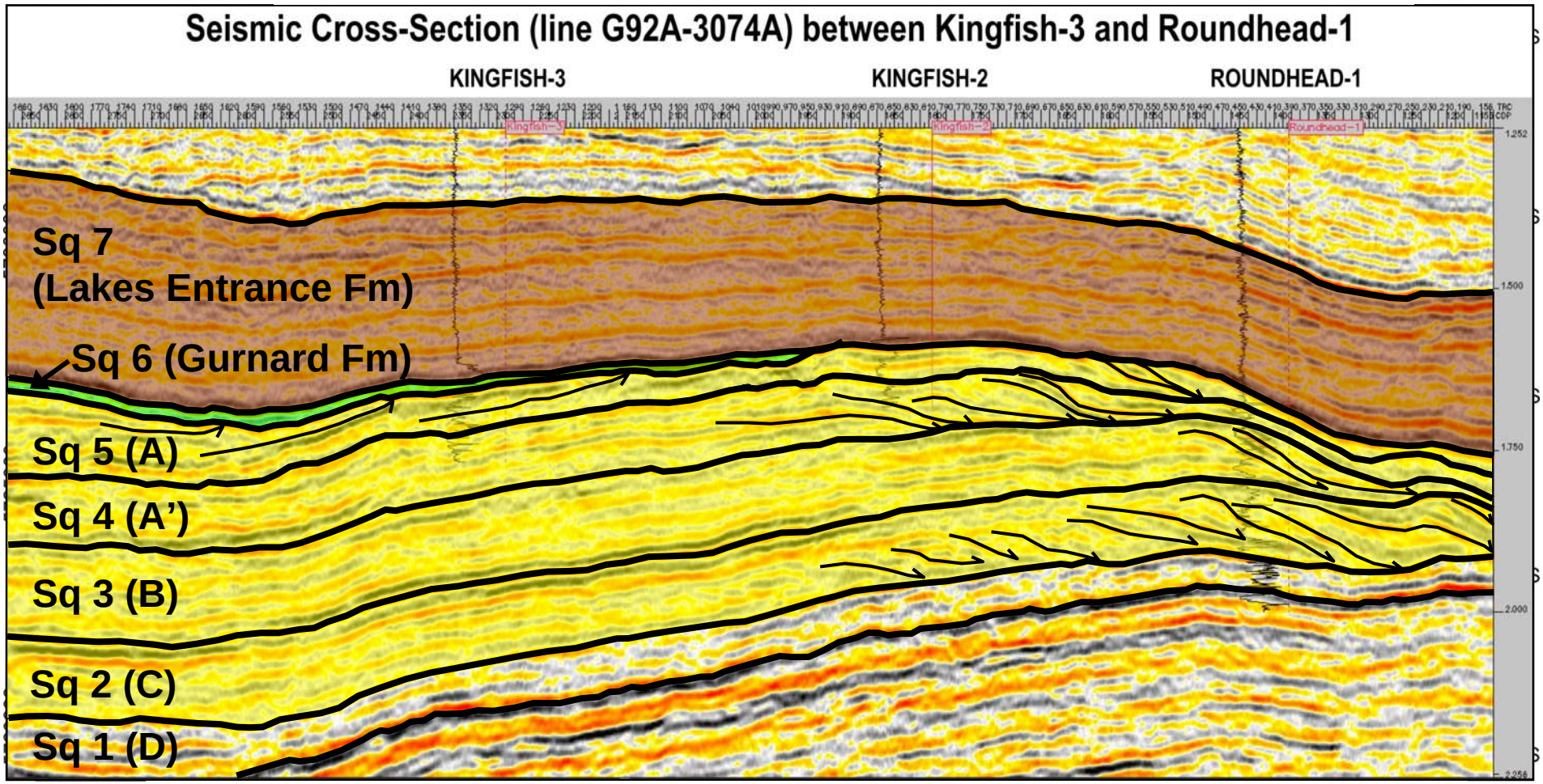
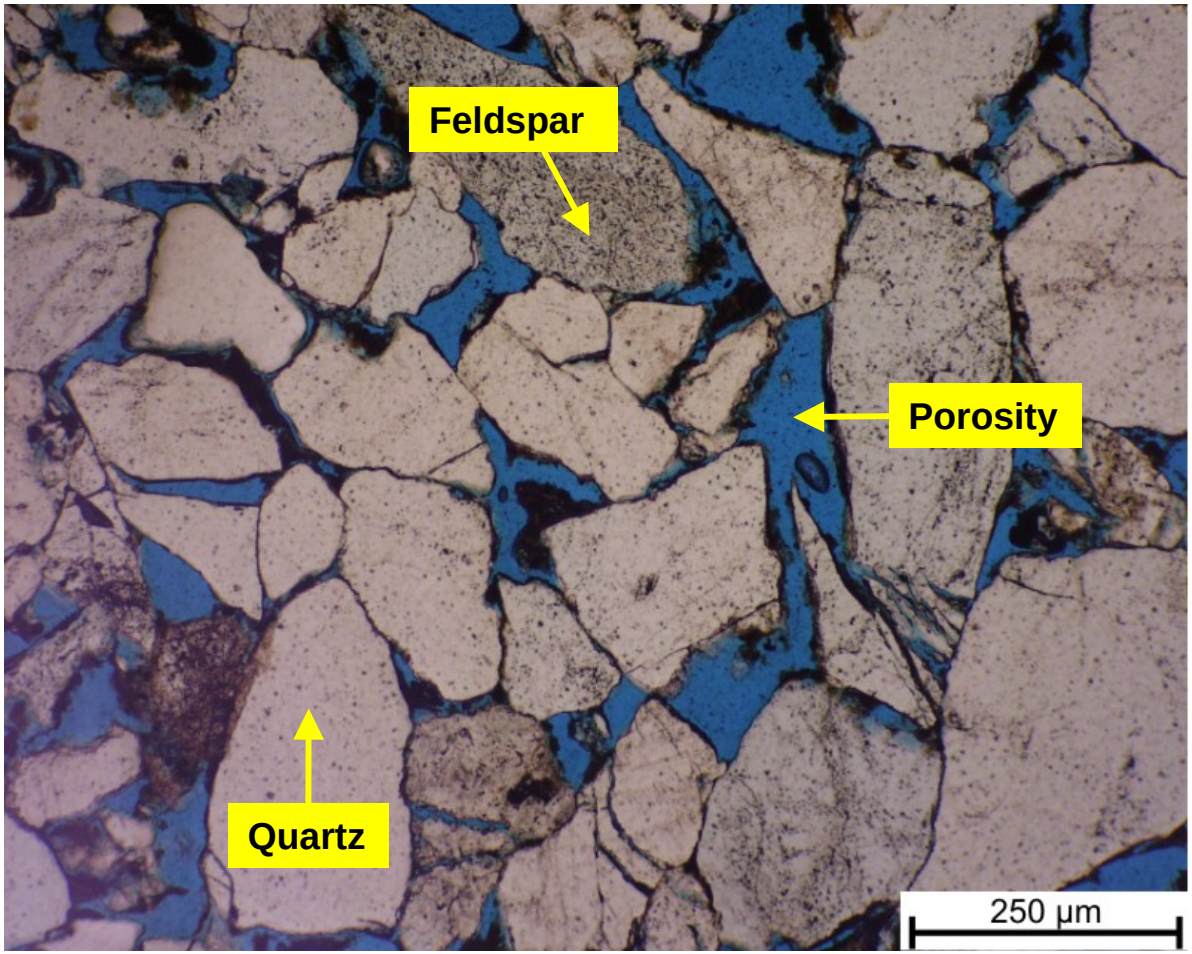
Sequence Stratigraphy



Injectivity: Reservoir Quality



Thin section micrograph: Kingfish Fm, nearshore facies

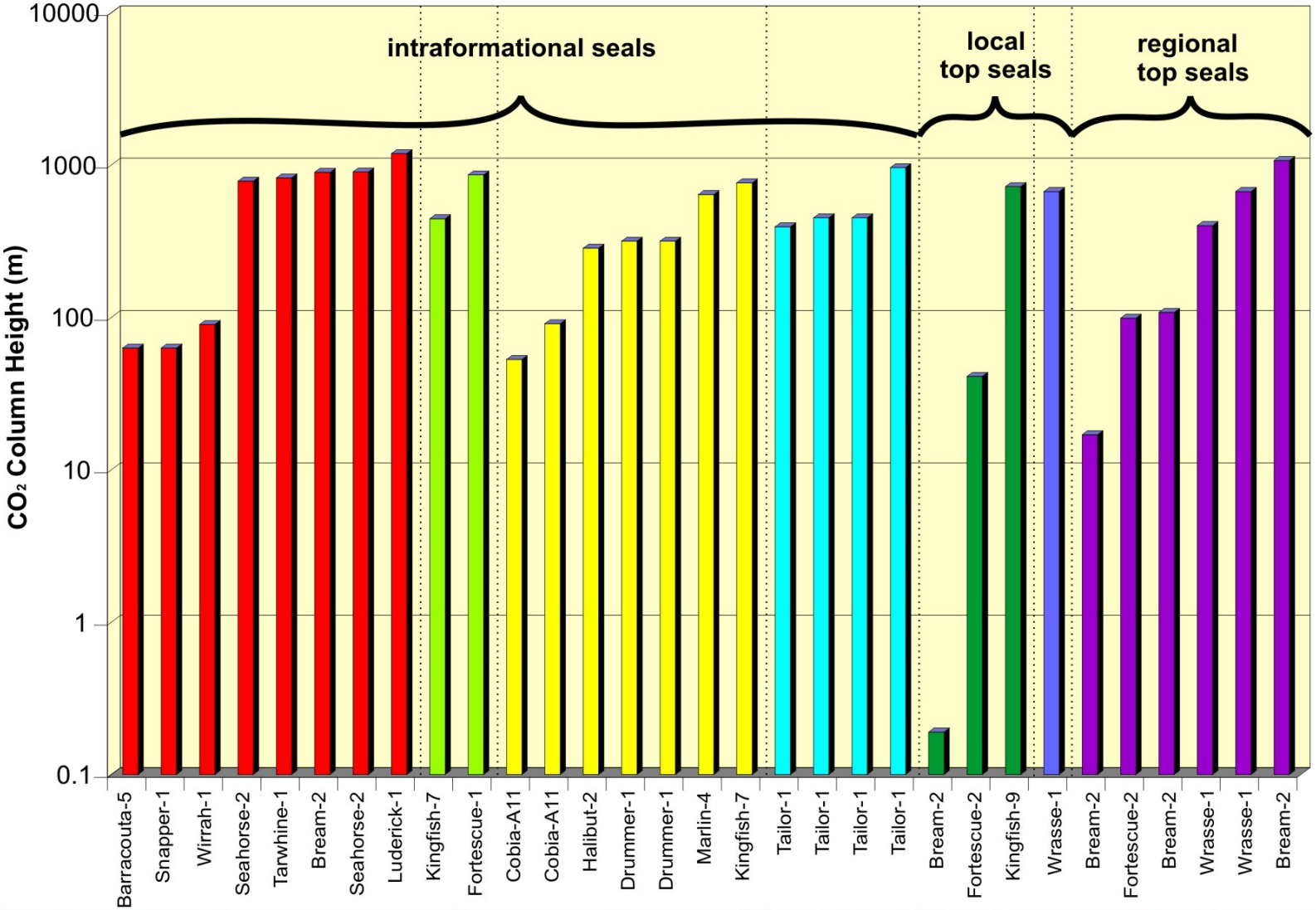
Kingfish Fm

- 15-30 % porosity
- 10-10,000 mD perm
- Good to excellent reservoir quality

Geochemical reactions

- Reservoir units lack minerals reactive to CO_2
- Injectivity unlikely to be compromised

Containment: Seal Capacity (MICP analysis)



Intra-formational seals

- **Average 517 m**

Local top seals

- **Average 360 m**

Regional top seal

- **Average 395 m**

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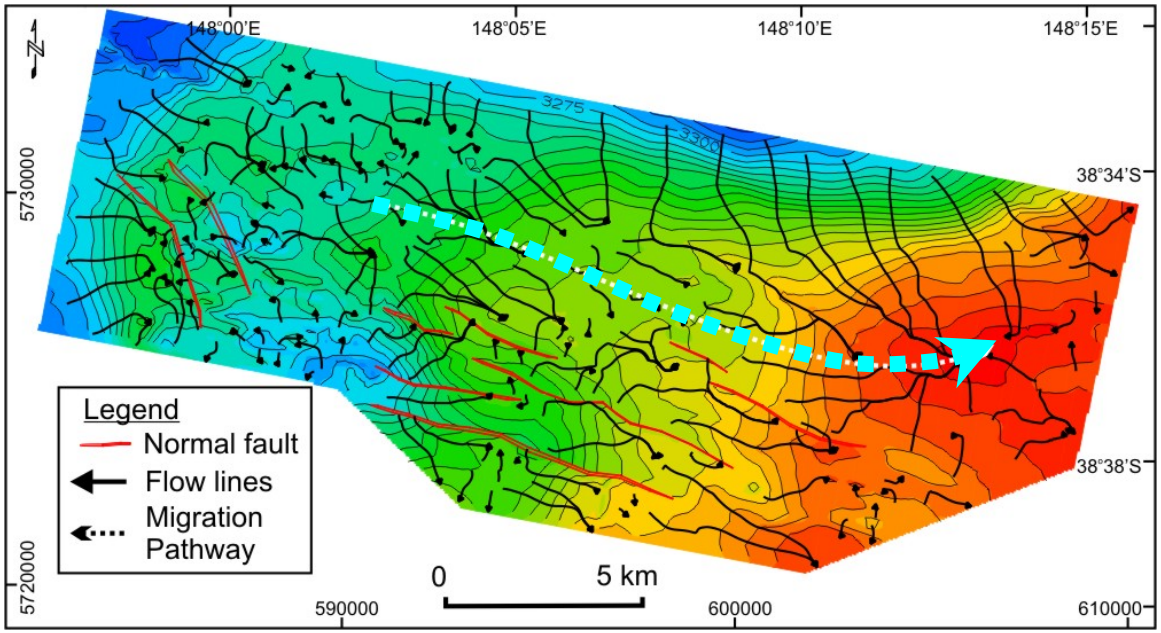
Containment: Migration Pathways

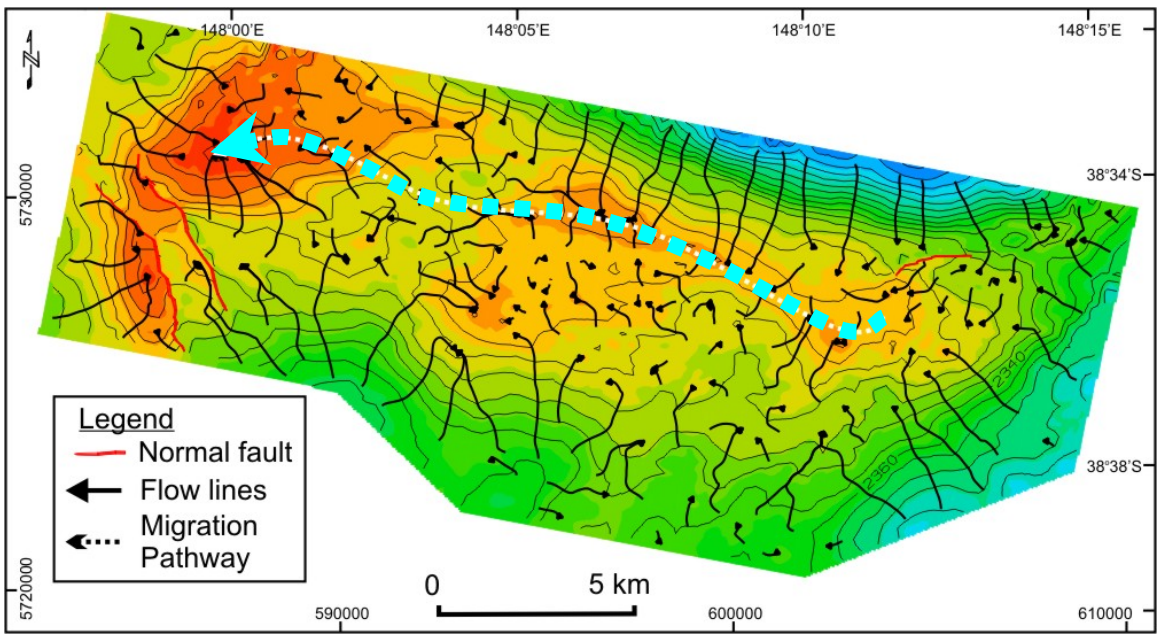


Intra-Latrobe Gp

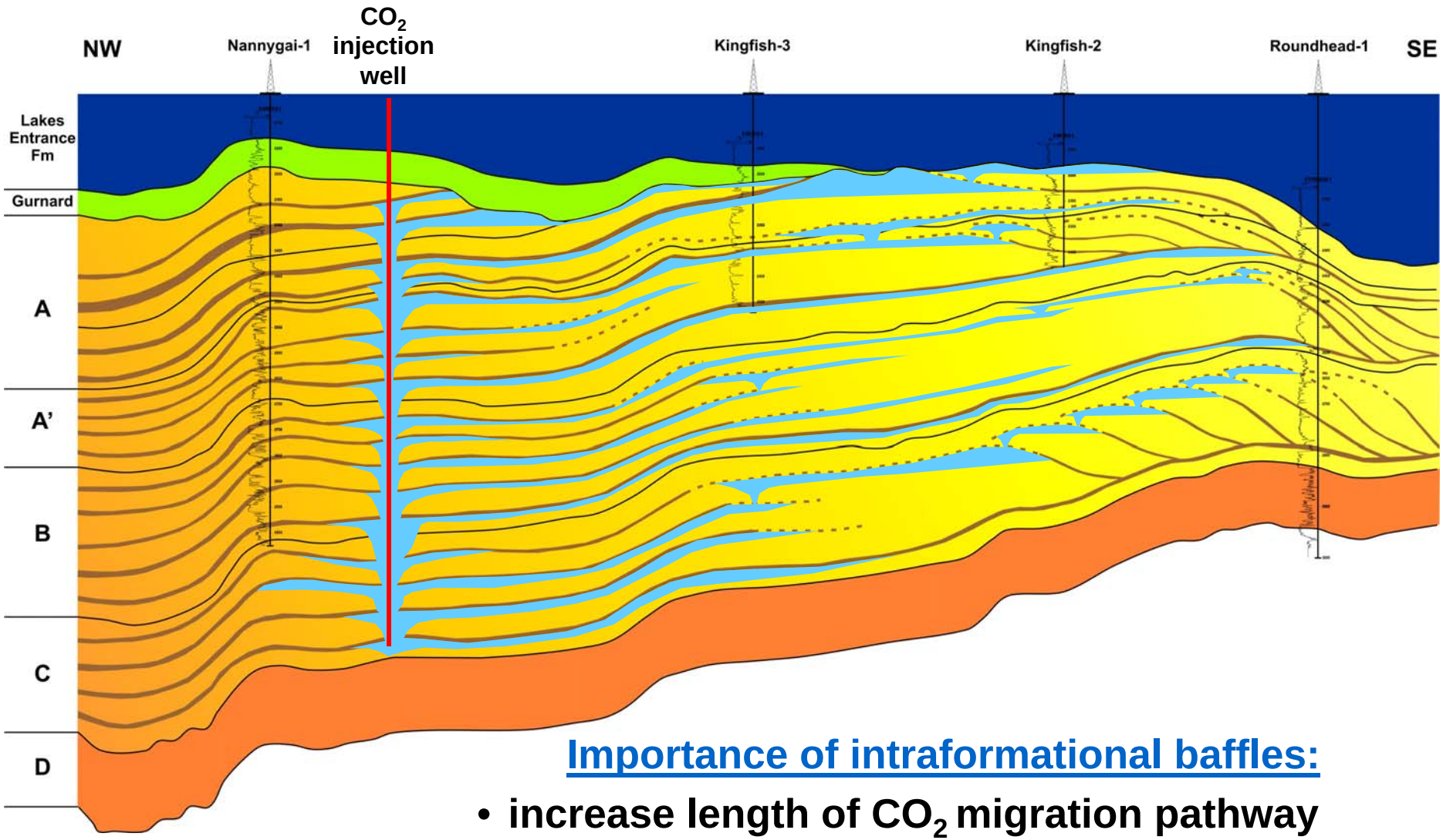
- Stratigraphy dips down to west
- CO_2 will migrate updip to east

Top Latrobe Gp

- Base regional seal dips down to east
- CO_2 will migrate updip to west (towards Bream)



Containment: Migration Pathways Concept



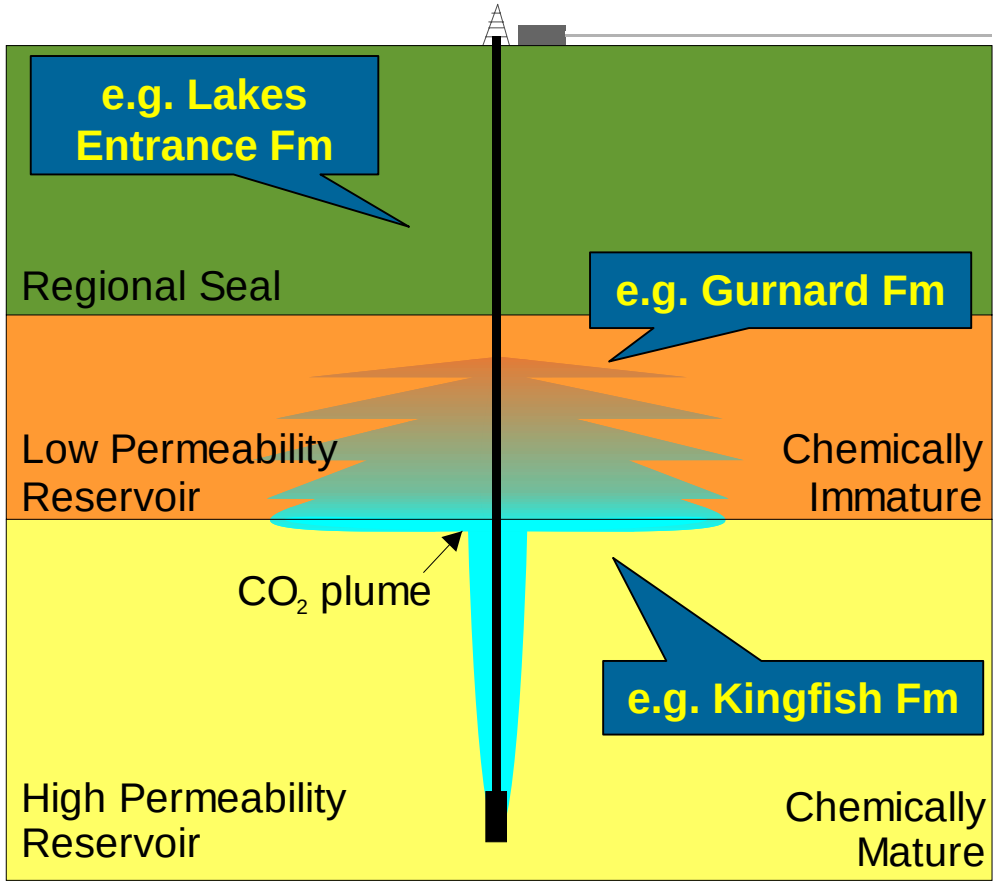
Importance of intraformational baffles:

- increase length of CO_2 migration pathway
- increase volume of pore space moved through

= greater residual gas trapping & dissolution

Containment: Geochemical Trapping

Ideal Reservoir System



Lakes Entrance Fm

- **High seal capacity**
- **Quartz & illitic-smectite**

= limited mineral reactions

Gurnard Fm

- **Low permeability**
- **Calcium, iron & magnesium-bearing minerals**

= significant potential for mineral trapping of CO_2

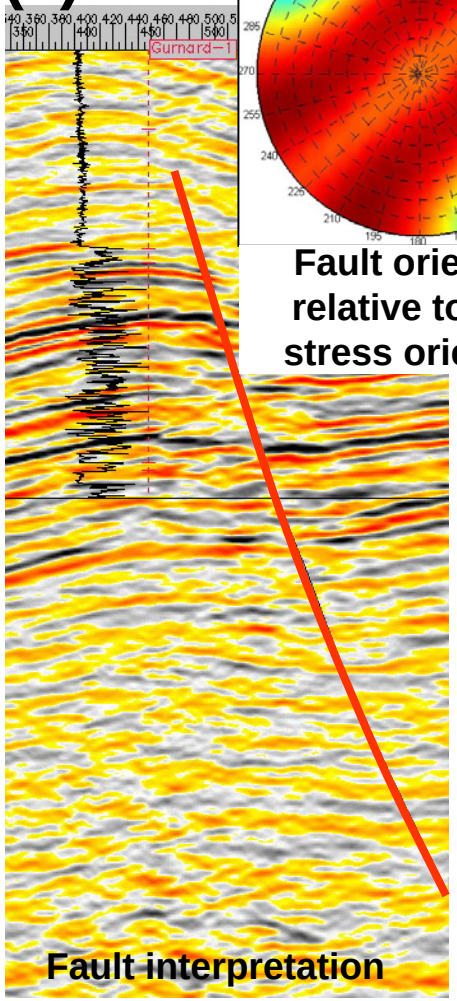
Kingfish Fm

- **Moderate to high permeability**
- **Non-reactive minerals**

= limited mineral reactions

Containment: Geomechanics

(1)



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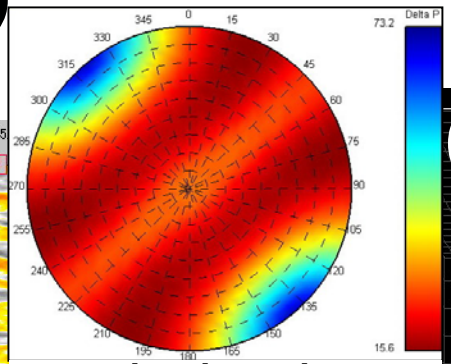
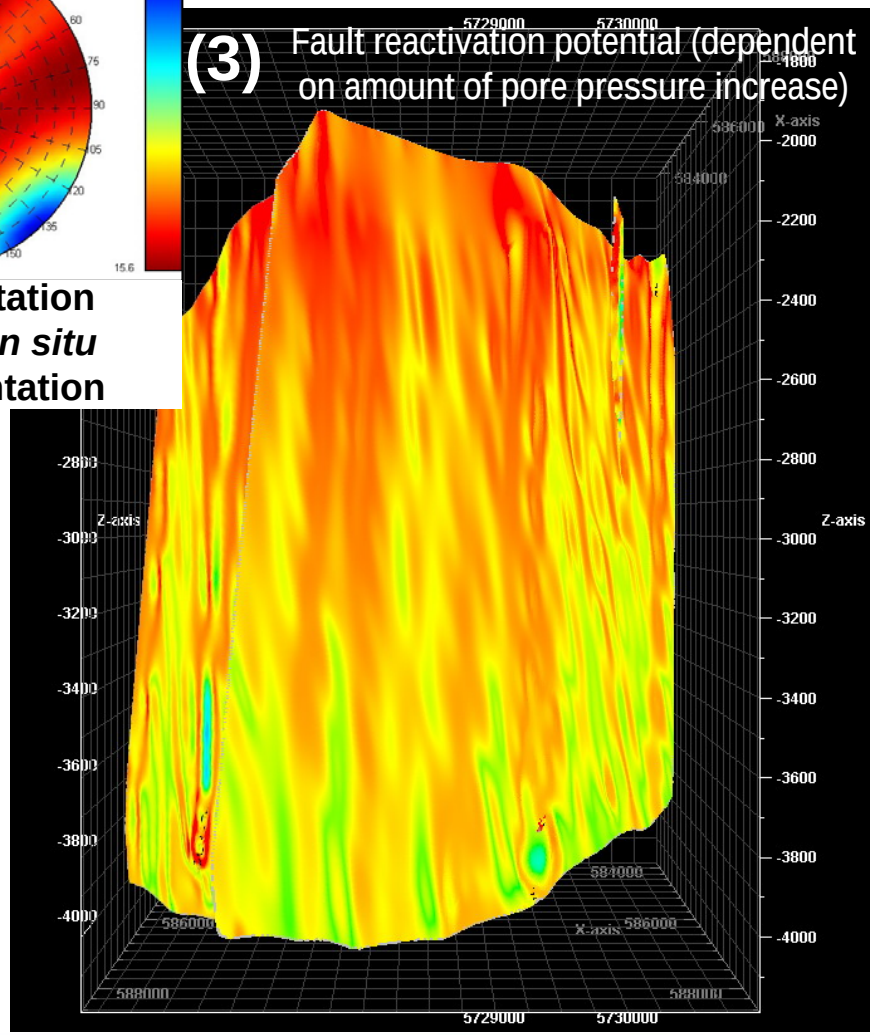


Fault orientation relative to *in situ* stress orientation

(3) Fault reactivation potential (dependent on amount of pore pressure increase)



Seismically-resolvable faults

- 3 cut the top Latrobe unconf.
- 7 terminate within Latrobe Gp
- Most have moderate to high fault reactivation potential
- However, most not in immediate migration pathway

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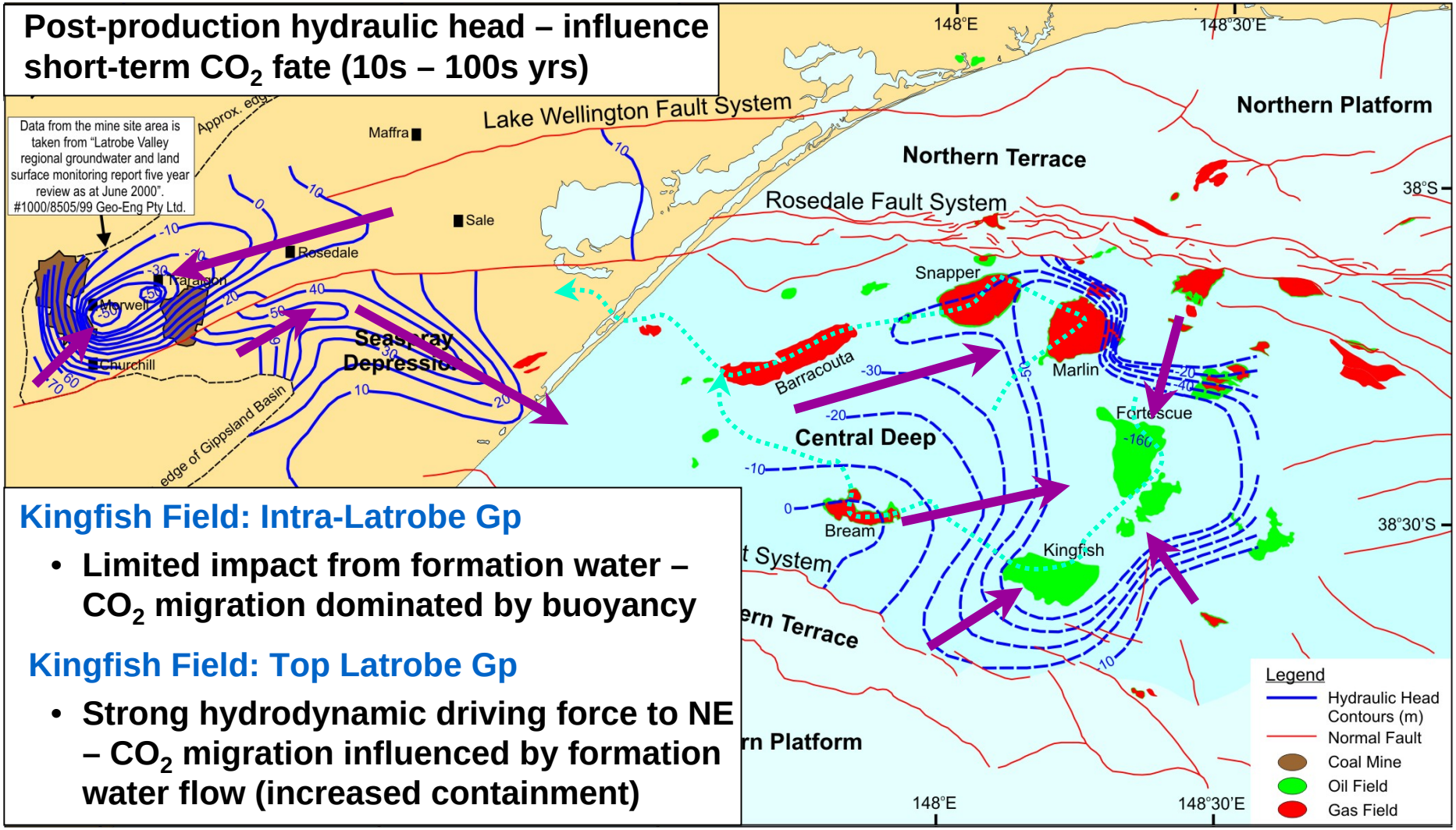
Containment: Hydrodynamics

Post-production hydraulic head – influence short-term CO_2 fate (10s – 100s yrs)



Kingfish Field: Intra-Latrobe Gp

- **Limited impact from formation water – CO_2 migration dominated by buoyancy**

Kingfish Field: Top Latrobe Gp

- **Strong hydrodynamic driving force to NE – CO_2 migration influenced by formation water flow (increased containment)**

CO_2 buoyancy migration at top Latrobe

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Capacity

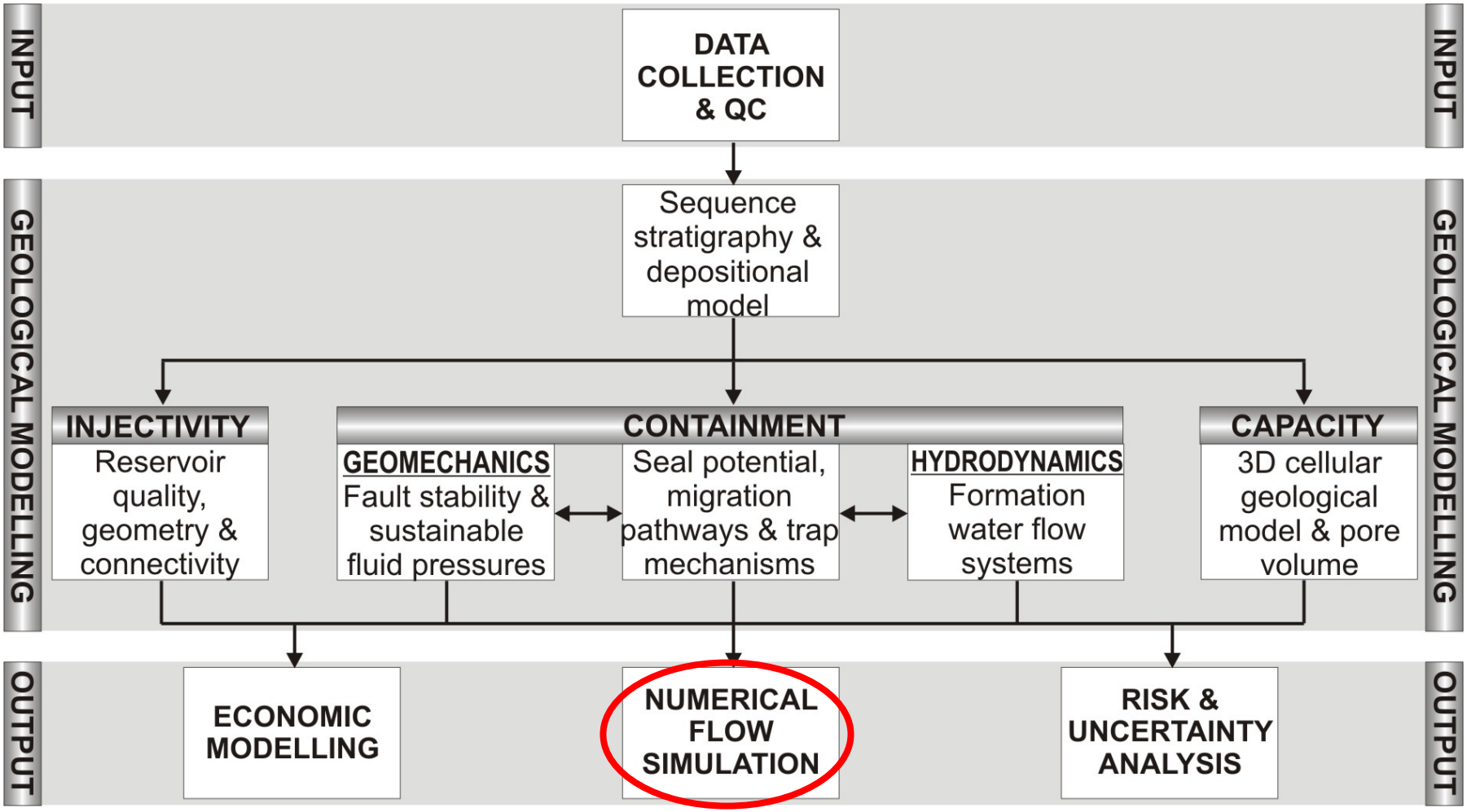
CO_2 Storage Capacity

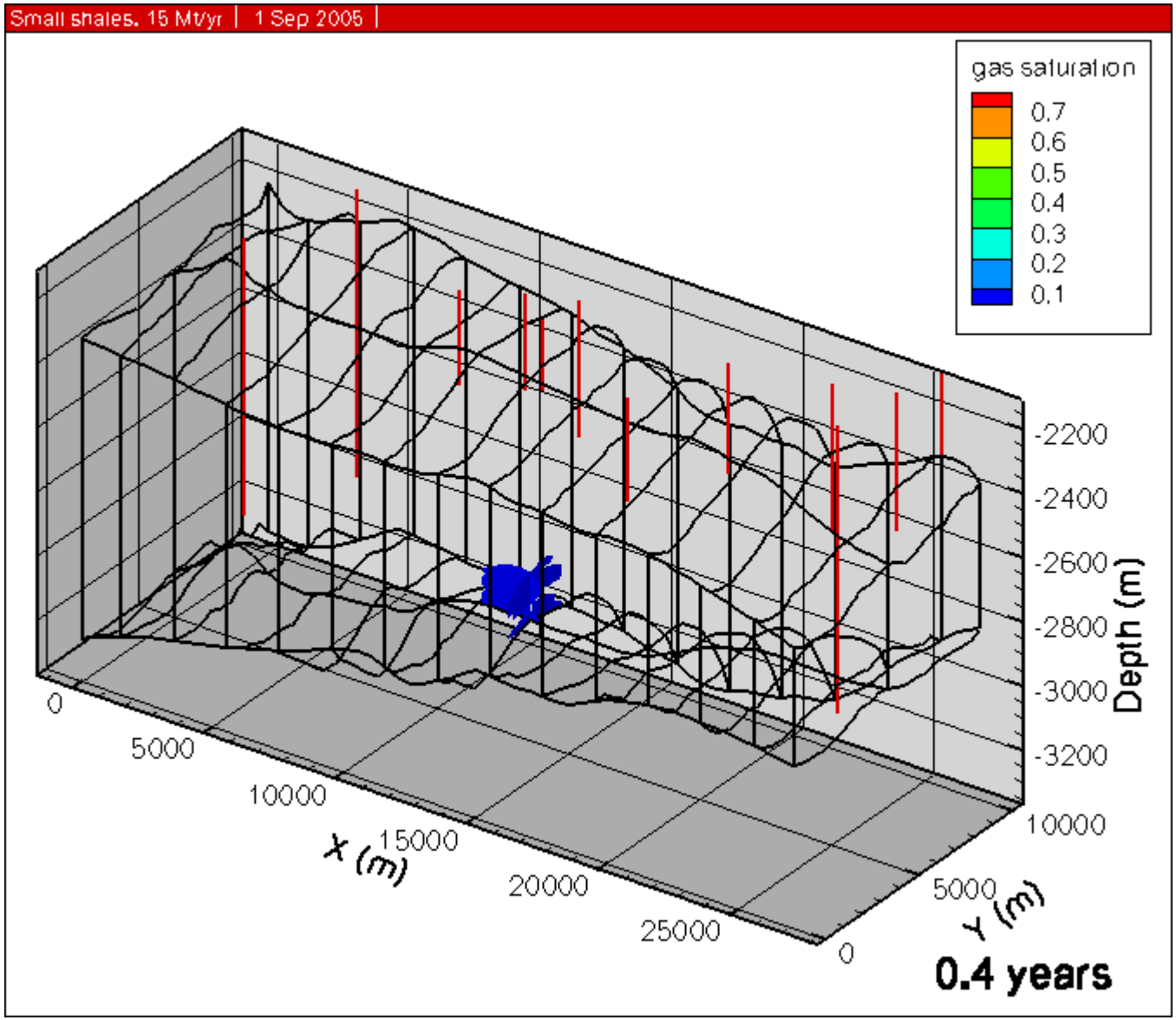
- Available pore volume calculated geologically
- Numerical simulation required to verify pore volume used (sweep efficiency)
- Sweep efficiency dependent on: rate of CO_2 migration, dissolution into formation water, precipitation of new minerals, fill-to-spill structural closures along migration path

Kingfish Field

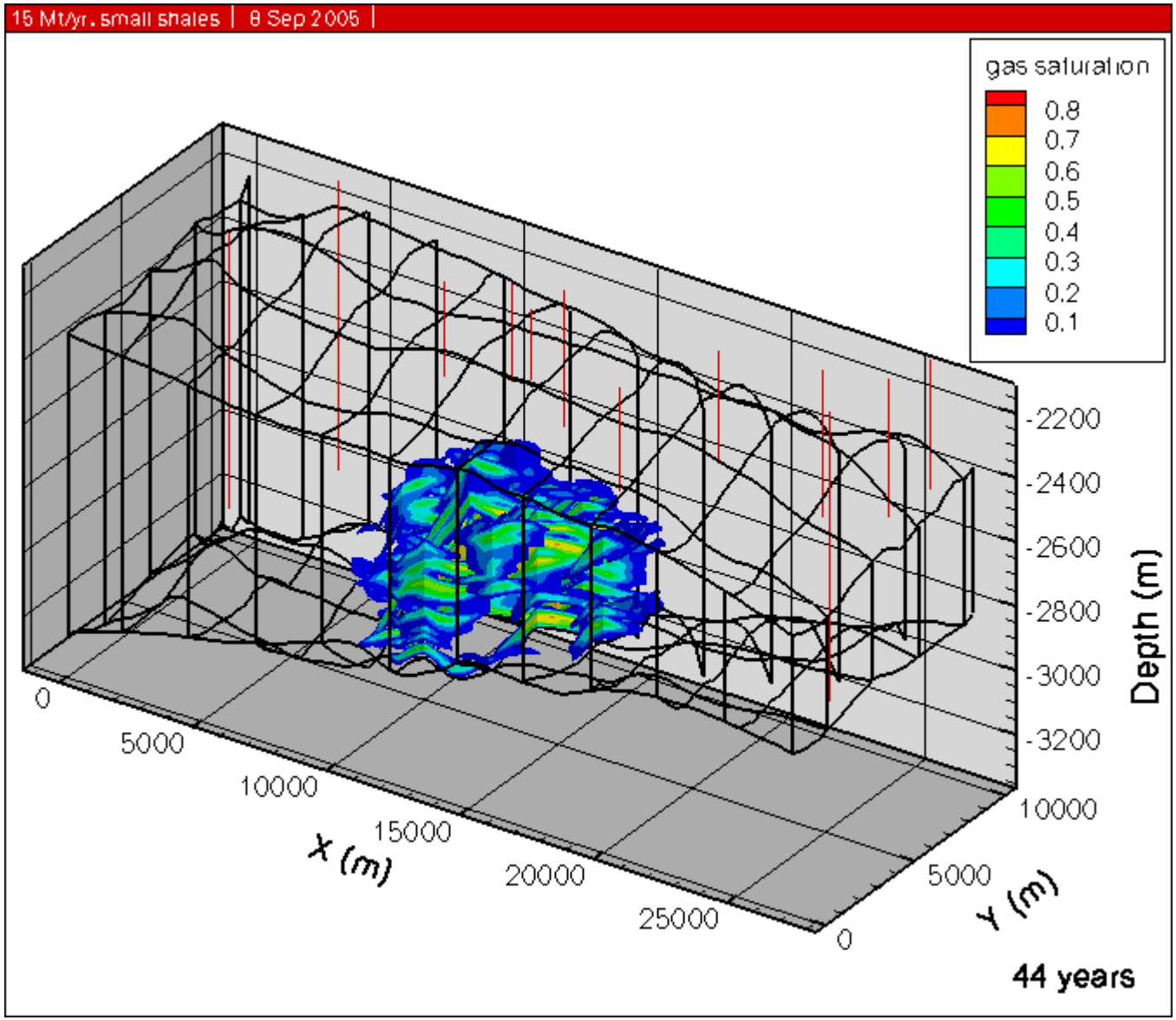
- Calculated structural closure capacity (existing oil zone) and deeper intra-Latrobe stratigraphy
- Combined capacity > 600 Mt (sufficient for 15 Mt/y for 40 years)
- Intra-Latrobe stratigraphy 3 times the capacity of the structural closure – demonstrates how a deeper injection strategy may provide significantly more CO_2 storage capacity

Numerical Flow Simulation

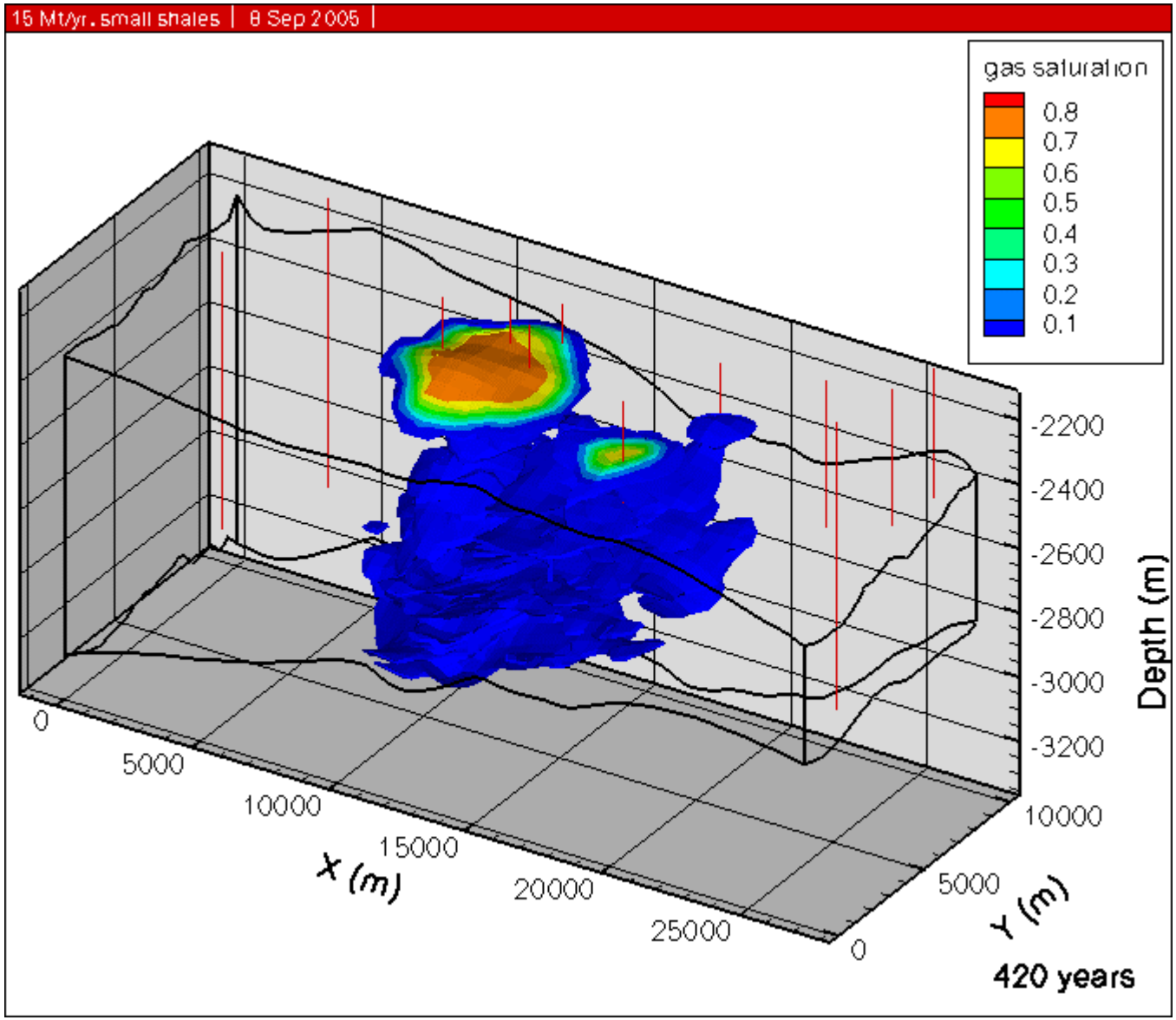




- **15 Mt/y for 40 years**
- **Post-injection small shales 0–40 yrs**



- **15 Mt/y for 40 years**
- **Post-injection small shales 40–400 yrs**



- **15 Mt/y for 40 years**
- **Post-injection small shales 400–1140 yrs**

Simulation results:

- **Injection rate achievable – lower permeability or extensive shale barriers require more wells**
- **Migration time to the oil-bearing zone is 40-200 years for deep injection – less for shallow injection, more for wider shale barriers**
- **Storage capacity sufficient with deep injection – more CO_2 trapped as residual gas**

Conclusions

Suitability of Kingfish Field/Gippsland Basin as CO_2 geological storage site:

- **Complex stratigraphic architecture which slows vertical migration and increases residual gas trapping**
- **Non-reactive reservoir units with high injectivity**
- **Geochemically-reactive, low permeability reservoir just below regional seal to provide additional mineral trapping**
- **Several depleted oil fields to provide storage capacity coupled with transient flow regime that enhances containment**
- **Long migration pathways beneath competent regional seal**
- **Kingfish Field, in conjunction with other sites (e.g. Fortescue, northern gas fields), indicate that Gippsland Basin has sufficient capacity to store very large volumes of CO_2.**

Site characterisation for CO_2 geological storage:

- **Geological variability requires sites to be independently assessed, although similar workflow can be applied (i.e. injectivity, containment, capacity)**
- **Best addressed by multidisciplinary approach (i.e. detailed geoscience, engineering, economics and risk assessment) to provide integrated and comprehensive site characterisation**

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